

Lunar Testing of Mars Vehicles

Lunar test of
Mars lander

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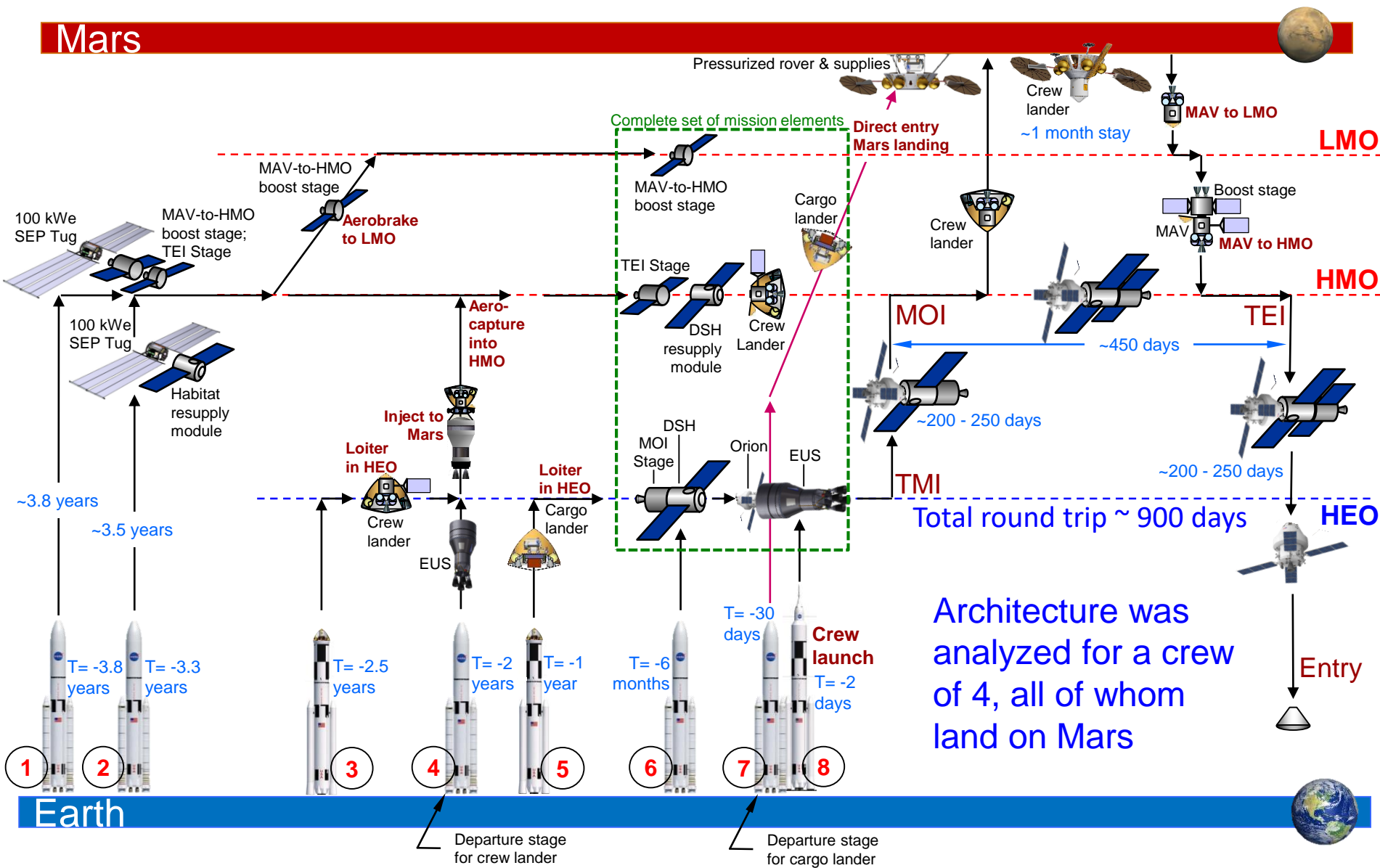
Humans to Mars Summit

May 10, 2017

Minimal Architecture Short Surface Stay Concept


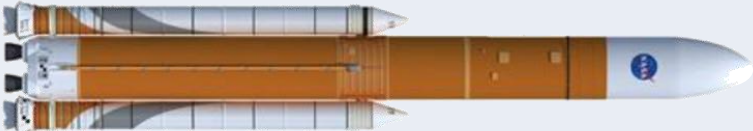
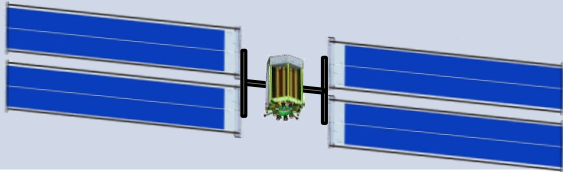
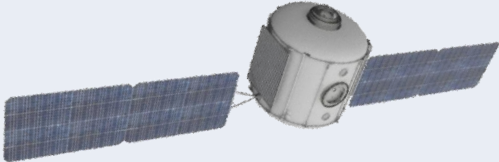
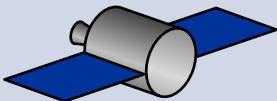
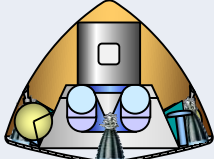
1 month surface stay; Crew of 4 to surface; 8 SLS launches

Mars

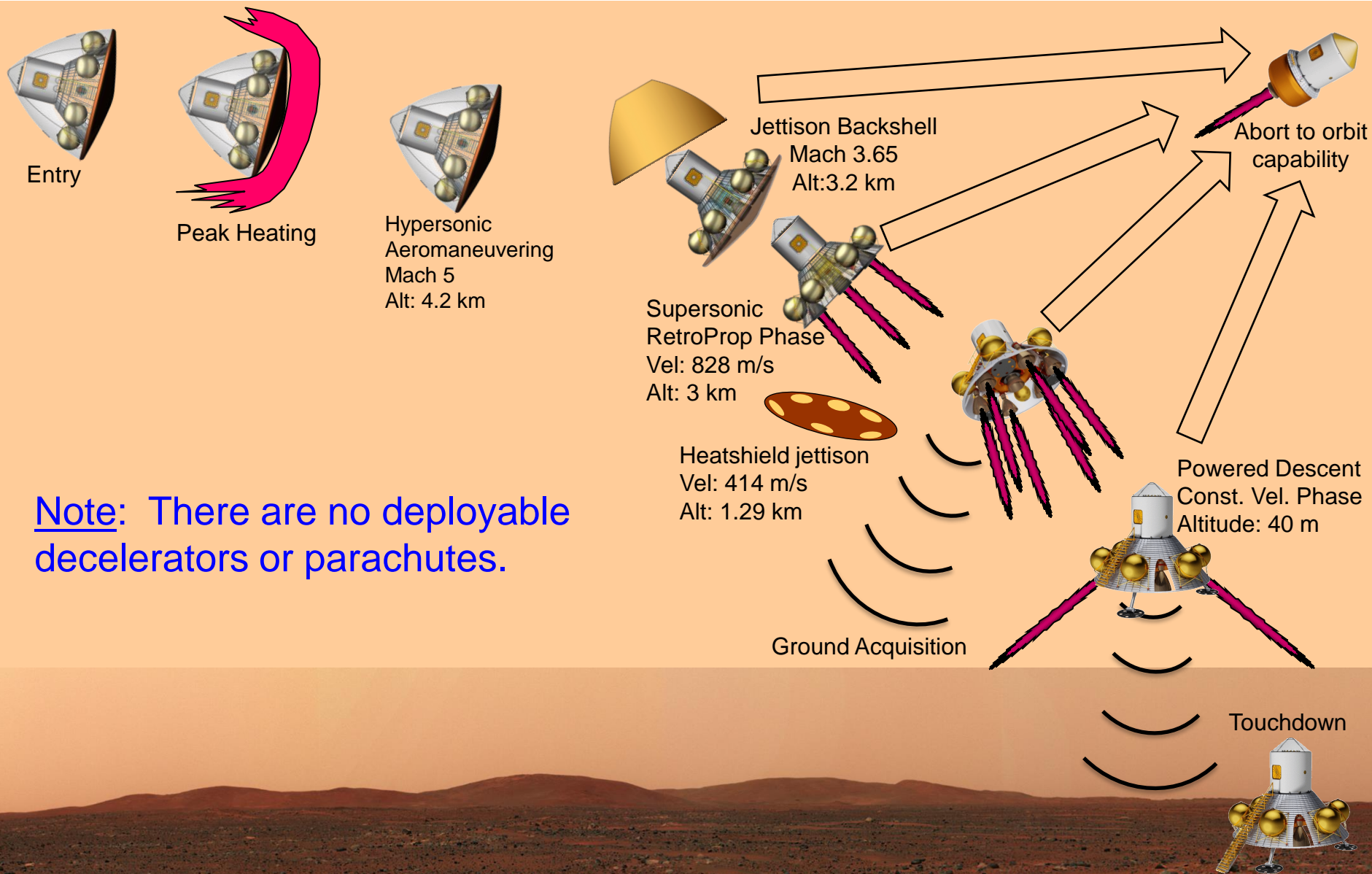


Earth

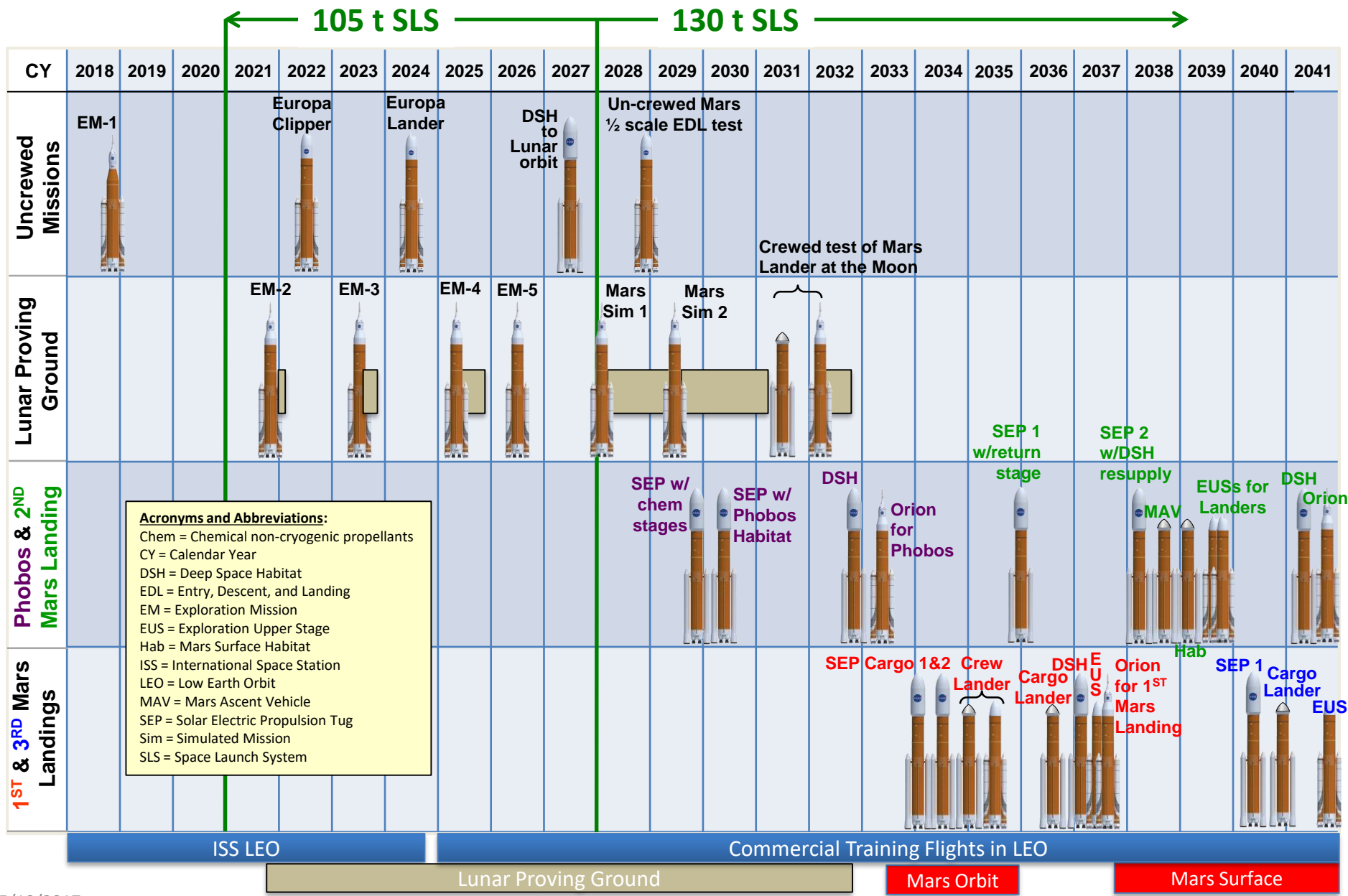
Six Vehicles to Enable Crewed Missions to Mars

Vehicles	# Vehicles per Mission
Orion 	1
SLS 	8
SEP Tug ~100 kWe 	2
Deep Space Habitat (One is a resupply version) 	2
In-Space Chemical Propulsion Stage 	3
Mars Lander (One crew and one cargo) 	2

EDL Concept for Crewed Mars Lander



Notional SLS Flight Scenario



Plan Right-to-Left, not Left-to-Right



- To be cost effective and retire risks, the Lunar Proving Ground should focus on what is required to achieve the end result
- The right side of the schedule should drive the left side
- Cislunar operations should focus on testing and verification of the vehicles and operational procedures to conduct successful missions to Mars
 - Orion
 - Deep Space Habitat
 - In-Space Propulsion
 - Mars lander and MAV
 - Mars orbital and surface operations and Earth ground operations
- The cislunar program for H2M should be what the Apollo 7-10 missions were to Apollo 11

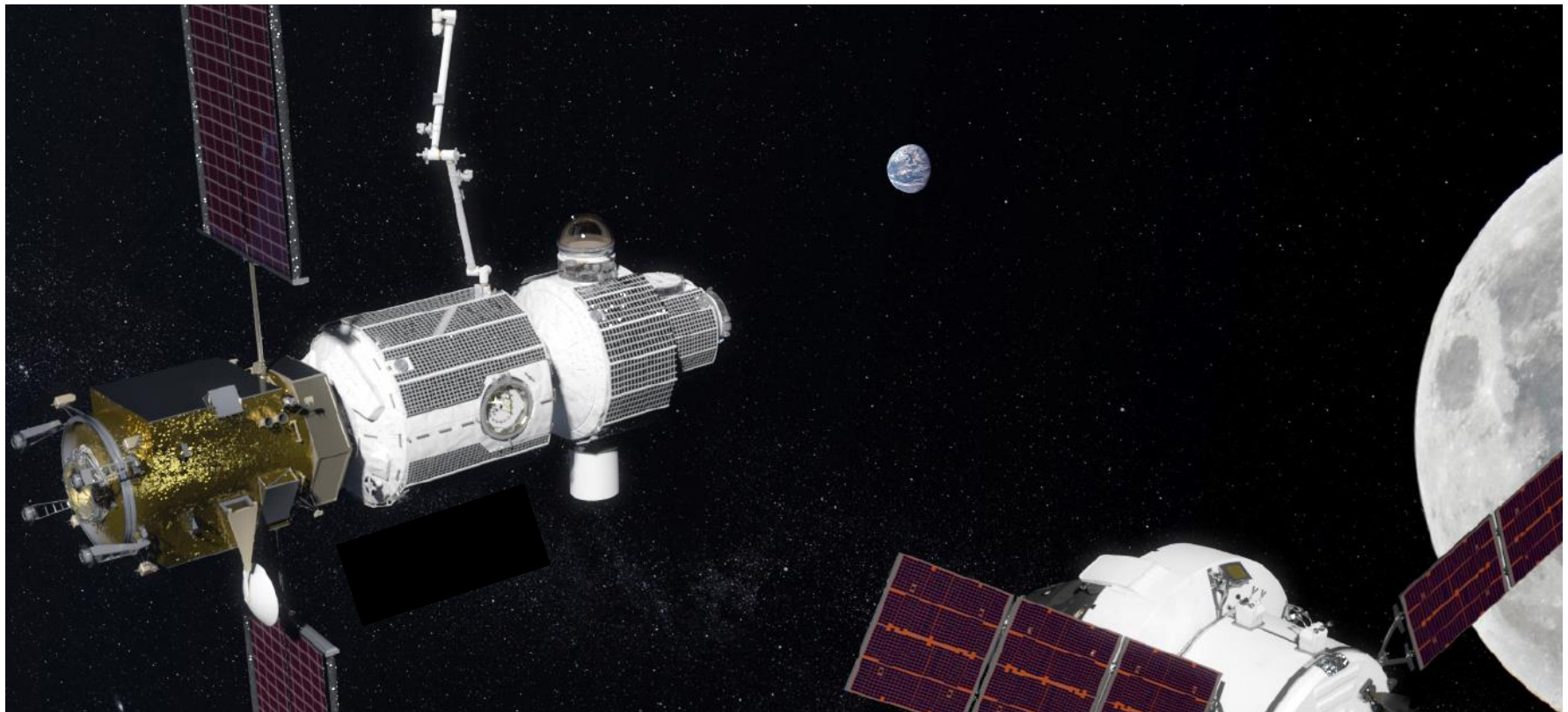
Testing at Deep Space Gateway



Humans to Mars



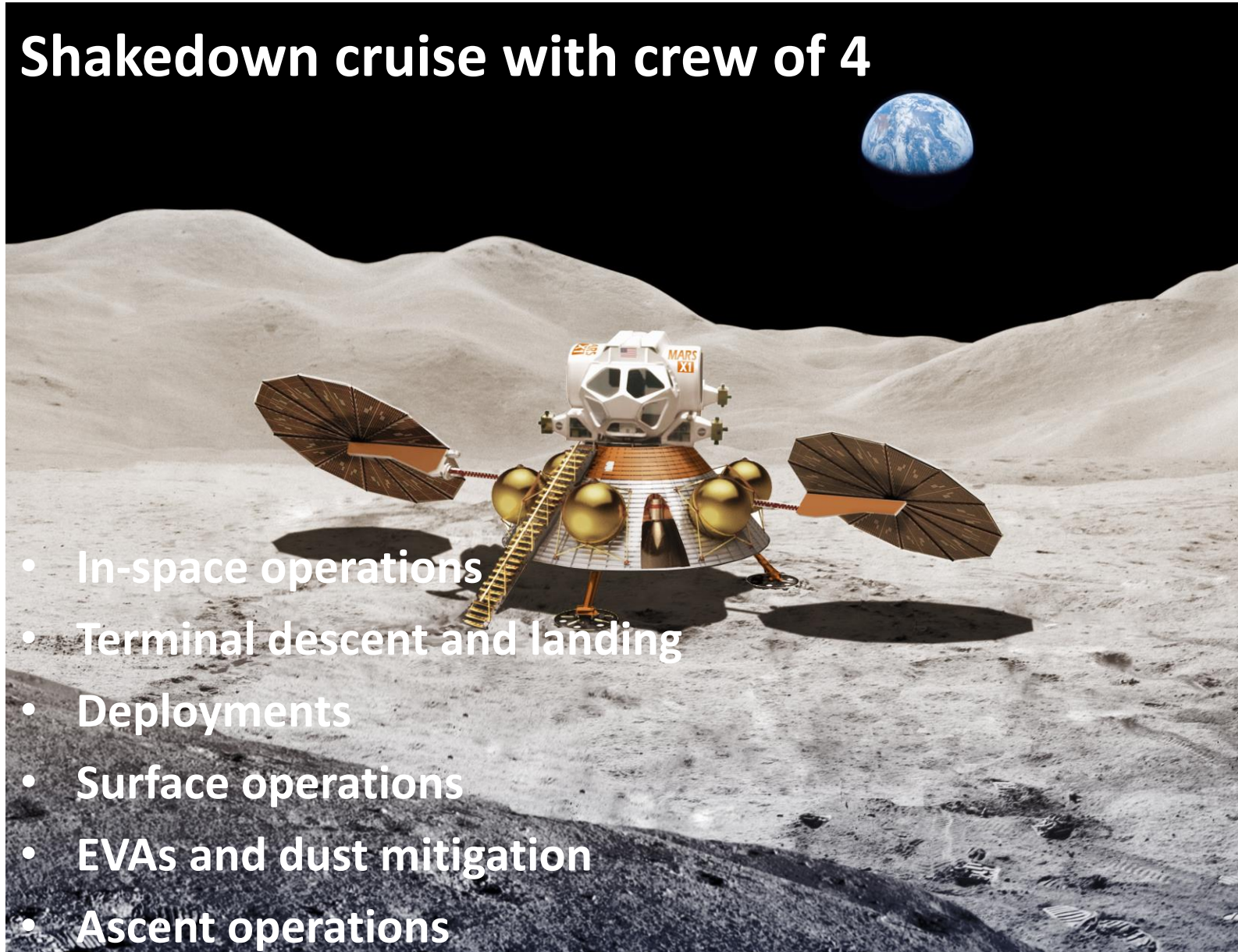
- Provides capability to conduct testing of Mars vehicles in cislunar space
- Could support lunar landing missions by international partners
- Could support lunar landing test of Mars lander



Notional Lunar Test of Mars Lander

Shakedown cruise with crew of 4

- In-space operations
- Terminal descent and landing
- Deployments
- Surface operations
- EVAs and dust mitigation
- Ascent operations



Notional Verification Table for H2M Lander

Humans to Mars

Mission Phase	Function	Analysis	Earth Test	Red Dragon	Sub-Scale Robotic EDL Test at Mars	Space Test of Human Lander	Lunar Test of Human Mars Lander	Mars Cargo Landing Before Crewed Landing	Comments
Cruise	System Qual for flight to Mars	no	partial	no	no	complete	complete	partial	
	Pre-entry configuring	no	partial	no	no	complete	complete	partial	
	Heatshield function	partial	partial	partial	High fidelity	no	no	complete	
	Hypersonic aeromaneuvering	partial	possible	partial	High fidelity	no	no	complete	
	Supersonic Retro-Propulsion	partial	possible	Adequate	High fidelity	no	no	complete	
EDL	Heatshield separation	partial	possible	no	High fidelity	not flight-like	not flight-like	complete	
	Backshell Separation	partial	possible	no	High fidelity	not flight-like	not flight-like	complete	
	Sensor operation	no	partial	partial	High fidelity	no	High fidelity	complete	Test interplay with software
	Terrain Relative Nav & precision landing	partial	partial	partial	High fidelity	no	partial	complete	
	Terminal constant V descent	partial	possible	no	High fidelity	no	High fidelity	complete	Need representative low gravity
	Landing gear deploy	partial	partial	no	no	not flight-like	High fidelity	complete	Can't be qualified at sub-scale
	Touchdown and soil interaction	partial	partial	no	High fidelity	no	High fidelity	complete	Need representative low gravity
	Post-landing configuring	no	partial	no	no	no	complete	partial	Need representative low gravity
	Solar array and other deployments	partial	partial	no	no	not flight-like	High fidelity	complete	Need representative low gravity
	Crew surface functions in cabin	no	partial	no	no	no	complete	no	Need representative low gravity
Surface Ops	Cabin systems surface operations	no	partial	no	no	no	High fidelity	no	Need representative low gravity
	Crew preparation for EVA	no	partial	no	no	no	complete	no	Need representative low gravity
	EVA egress and ingress	no	partial	no	no	no	complete	no	Need representative low gravity
	Surface EVA equipment and mobility	no	partial	no	no	no	complete	no	Need representative low gravity
	End-to-end surface telecom	partial	partial	no	no	no	High fidelity	partial	Suit-rover-MAV-(relay)-Earth
	Deployment and ops of unpressurized rover	no	partial	no	no	no	complete	no	Need representative low gravity
	Crew surface science operations	no	partial	no	no	no	complete	no	Need representative low gravity
	Surface dust mitigation	no	partial	no	no	no	High fidelity	no	Need representative low gravity
	Crew post-EVA operations	no	partial	no	no	no	complete	no	Need representative low gravity
	Preparations for ascent	no	partial	no	no	no	complete	no	May include dumping equipment
Ascent	MAV ignition and separation	partial	partial	no	no	not flight-like	High fidelity	no	Need representative low gravity
	MAV ascent propulsion	partial	partial	no	no	complete	complete	no	
	MAV orbital operations	no	partial	no	no	complete	complete	no	
Off-Nominal	Abort to orbit during EDL	Best effort	possible	no	no	no	no	no	Testing may not be feasible
	Post-landing abort to orbit	Best effort	no	no	no	no	simulation	no	Testing may not be feasible
	Failed or partial solar array deployment	no	partial	no	no	no	simulation	no	Need representative low gravity
	Failed or interrupted telecom link(s)	no	partial	no	no	no	simulation	no	Need flight-like geometry
	Rover breakdown	no	partial	no	no	no	simulation	no	Need representative low gravity
	Incapacitated crew member	no	partial	no	no	no	simulation	no	Need representative low gravity
	Loss of cabin pressure	no	partial	no	no	partial	simulation	no	Need representative low gravity